

NASA'S STANDARD MEASURES DURING BED REST: ADAPTATIONS IN THE CARDIOVASCULAR SYSTEM

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Bed rest is a well-accepted analog of space flight that has been used extensively to investigate physiological adaptations in a larger number of subjects in a shorter amount of time than can be studied with space flight and without the confounding effects associated with normal mission operations. However, comparison across studies of different bed rest durations, between sexes, and between various countermeasure protocols have been hampered by dissimilarities in bed rest conditions, measurement protocols, and testing schedules. To address these concerns, NASA instituted standard bed rest conditions and standard measures for all physiological disciplines participating in studies conducted at the Flight Analogs Research Unit (FARU) at the University of Texas-Medical Branch. Investigators for individual studies employed their own targeted study protocols to address specific hypothesis-driven questions, but standard measures tests were conducted within these studies on a non-interference basis to maximize data availability while reducing the need to implement multiple bed rest studies to understand the effects of a specific countermeasure. When possible, bed rest standard measures protocols were similar to tests nominally used for medically-required measures or research protocols conducted before and after Space Shuttle and International Space Station missions. Specifically, bed rest standard measures for the cardiovascular system implemented before, during, and after bed rest at the FARU included plasma volume (carbon monoxide rebreathing), cardiac mass and function (2D, 3D and Doppler echocardiography), and orthostatic tolerance testing (15- or 30-min of 80° head-up tilt). Results to-date indicate that when countermeasures are not employed, plasma volume decreases and the incidence of presyncope during head-up tilt is more frequent even after short-duration bed rest while reductions in cardiac function and mass are progressive as bed rest duration increases. Additionally, while plasma volume loss can be corrected and cardiac mass can be prevented with properly applied countermeasures, orthostatic tolerance is more difficult to protect when supine exercise is the only countermeasure. Similar results have been observed after space flight. Plasma volume, cardiac chamber volume, and orthostatic tolerance recover relatively quickly with resumption of ambulation and normal activity levels after bed rest but restoration of cardiac mass is prolonged.